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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.
08/825,360	03/28/97	LIAO	761/P7US/CVD

EXAMINER	
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ART UNIT	PAPER NUMBER
2814	

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DATE MAILED: 04/06/01

Please find below and/or attached an Office communication concerning this application or proceeding.

Commissioner of Patents and Trademarks

Advisory Action	Application No. 08/825,360	Applicant(s) LIAO ET AL.	
	Examiner Tuan Quach	Art Unit 2814	

--The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

THE REPLY FILED 26 March 2001 FAILS TO PLACE THIS APPLICATION IN CONDITION FOR ALLOWANCE. Therefore, further action by the applicant is required to avoid abandonment of this application. A proper reply to a final rejection under 37 CFR 1.113 may only be either: (1) a timely filed amendment which places the application in condition for allowance; (2) a timely filed Notice of Appeal (with appeal fee); or (3) a timely filed Request for Continued Examination (RCE) in compliance with 37 CFR 1.114.

PERIOD FOR REPLY [check only a) or b)]

a) ☒ The period for reply expires 5 months from the mailing date of the final rejection.

b) ☐ In view of the early submission of the proposed reply (within two months as set forth in MPEP § 706.07 (f)), the period for reply expires on the mailing date of this Advisory Action, OR continues to run from the mailing date of the final rejection, whichever is later. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the mailing date of the final rejection.

Extensions of time may be obtained under 37 CFR 1.136(a). The date on which the petition under 37 CFR 1.136(a) and the appropriate extension fee have been filed is the date for purposes of determining the period of extension and the corresponding amount of the fee. The appropriate extension fee under 37 CFR 1.17(a) is calculated from: (1) the expiration date of the shortened statutory period for reply originally set in the final Office action; or (2) as set forth in (b) above, if checked. Any reply received by the Office later than three months after the mailing date of the final rejection, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

1.☒ A Notice of Appeal was filed on *26 March 2001*. Appellant's Brief must be filed within the period set forth in 37 CFR 1.192(a), or any extension thereof (37CFR 1.191(d)), to avoid dismissal of the appeal.

2.☒ The proposed amendment(s) will be entered upon the timely submission of a Notice of Appeal and Appeal Brief with requisite fees.

3.☐ The proposed amendment(s) will not be entered because:

(a) ☐ they raise new issues that would require further consideration and/or search. (see NOTE below);

(b) ☐ they raise the issue of new matter. (see Note below);

(c) ☐ they are not deemed to place the application in better form for appeal by materially reducing or simplifying the issues for appeal; and/or

(d) ☐ they present additional claims without canceling a corresponding number of finally rejected claims.

NOTE: _____.

4.☐ Applicant's reply has overcome the following rejection(s): _____.

5.☐ Newly proposed or amended claim(s) _____ would be allowable if submitted in a separate, timely filed amendment canceling the non-allowable claim(s).

6.☐ The a)☒ affidavit, b)☐ exhibit, or c)☒ request for reconsideration has been considered but does NOT place the application in condition for allowance because: *see attachment*.

7.☐ The affidavit or exhibit will NOT be considered because it is not directed SOLELY to issues which were newly raised by the Examiner in the final rejection.

8.☒ For purposes of Appeal, the status of the claim(s) is as follows (see attached written explanation, if any):

Claim(s) allowed: _____.

Claim(s) objected to: _____.

Claim(s) rejected: *21-23, 25-43*.

Claim(s) withdrawn from consideration: _____.

9. ☐ The proposed drawing correction filed on _____ a)☐has b)☐ has not been approved by the Examiner.

10.☐ Note the attached Information Disclosure Statement(s)(PTO-1449) Paper No(s). _____.

11.☐ Other:

Tuan Quach
Primary Examiner

DETAILED ACTION

The proposed amendment filed March 26, 2001 would be entered upon appeal, the outstanding claims being 21-23 and 25-53. The Finality of the Office action mailed September 26, 2000 remains, the grounds of rejections are reproduced below.

The text of those sections of Title 35, U.S. Code not included in this action can be found in a prior Office action.

Claims 21-45 and 48-53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. in view of Ho et al., Hower et al., and Fu et al.

Bai et al. teach forming substrate 40, forming dielectric 41, patterning the dielectric layer to form trench 47, forming capturing layer 43 of titanium material having thickness between 5Ä and 500Å, forming blocking layer of titanium nitride having thickness between 10Å and 500 Å. See column 5 lines 1-33, column 8 lines 7-57, Fig. 3, column 10 lines 4-49. Note that the inventive feature of the capturing layer, the blocking layer, the refractory metal, the refractory metal nitride, and the laeyr thicknesses as characterized correspond to the claimed invention in claims 1-20 of Bai et al., column 10 line 5 to column 12 line 32, e.g., claim 1 lines 4-11, claim 3 line 3, claim 4 line 3, claim 9 lines 1-4, claim 10 lines 4-12, claim 11 lines 3-5, claim 16 lines 1-13, claim 17 line 3, claim 18 line 3, claims 19 and 20 lines 1-4. The claimed parameters, e.g., thickness of less than 130Å, width less than 3000Å, aspect ratios greater than 3.33 is anticipated given the range taught in Bai et al. Any range and combined range claimed not anticipated by Bai et al. would have been obvious to one skilled in the art given the teachings of Bai et al., would have been obvious to one skilled in the art given the

teachings of Bai et al., e.g., column 5 lines 6 et seq., to optimize the barrier thickness and to obtain the desired resistance of the interconnect. Any parameters not anticipated would have been obvious and would have been within the purview of one skilled in the art to obtain the desired trench width and aspect ratio.

The reference as applied above does not recite the plasma annealing of the titanium nitride barrier layer.

Ho et al. teach plasma reaction of titanium nitride in suitable gases, e.g., oxygen, nitrogen, to fill the grain boundaries hence improving barrier characteristics. See column 7 line 28 to column 8. The use of nitrogen or hydrogen as the gas to stuff the nitride is also taught. See column 7 lines 4-27, column 10 lines 3-20.

Hower et al. teach plasma treatment of titanium nitride to reduce silicon movement therethrough and to reduce interface defects. See column 2 line 56 to column 3 line 30.

Fu et al. teach plasma treatment of titanium nitride in argon wherein the treatment smoothens the TiN surface and improves wettability. See column 2 line 48 to column 3 line 16.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the Bai et al. process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within the purview of one skilled in the art to have selected the desired conventional plasas, the conventional electrical biasing and rf

signal, to have employed single chamber for deposition and annealing, and to employe conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited above and the use of electrical biasing and rf signal as claimed.

Regarding claims 32-39 and 51, note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogens. See, e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Claims 46 and 47 are rejected under 35 U.S.C. 103(a) as being unpatentable over Bai et al. in view of Ho et al., Hower et al., and Fu et al. as applied to claims 21-45 and 48-53 above, and further in view of Dixit et al.

The references as applied above do not recite the upper metallization layer of tungsten.

Dixit et al. teach the filling of tungsten on the titanium/titanium nitride to complete the interconnection having low resistivity. See column 5 lines 3-57, column 7 line 34 to column 8 line 13.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed tungsten as interconnection since such is conventional and advantageous as taught in Dixit et al.

Claims 21-23 and 25-53 are rejected under 35 U.S.C. 103(a) as being unpatentable over Dixit et al. or Sandhu et al taken with Suguro et al. and further in view of Ho et al., Hower et al., and Fu et al.

Dixit et al. teach forming channels 16 through insulatinglayer 14, forming titanium 18, e.g., about 100 angstroms, forming titanium nitride thereon, e.g., to about 250 angstroms using conventional deposition method. Well known alternative refractory metals and metal nitrides and alternative deposition techniques are also shown. Subsequent formation of metallization and etchback are also taught. See column 4line 64 to column 7 line 11.

Sandhu et al. also teach forming channels 31 in insulating layer 32, forming titanium layer 35, forming titanium nitride barrier layer 41, forming tungsten or aluminum or copper thereon. See column 6 line 61 to column 7 line 33.

Thus Dixit et al. or Sandhu et al. lack anticipation in that the metal nitride having of less than 130 angstrom and the plasma annealing are not taught.

Suguro et al. teach the use of TiN as barrier layer wherein optimization of layer thickness of the titanium nitride is also taught, including the use of TiN thickness of 4 nm, 7 nm, and 10 nm; see the abstract, the paragraph bridging pages 280 and 281, wherein TiN thickness as low as 10 nm was employed.

Ho et al., Hower et al., and Fu et al. are applied as above.

It would have been obvious to one skilled in the art in practicing Dixit et al. or Sandhu et al. to have selected the desired thickness of the nitride barrier layer since such thickness variation and optimization are well within the purview of one skilled in the art as evidenced by Suguro et al., including the selection of the thickness of less than 13 nm, given the thickness taught by Suguro et al. The claimed parameters, e.g., thickness of less than 130 Å, thus would have been obvious given the range taught in Suguro et al. The use of thin adhesion layer employeing conventional processing would have been obvious given the teaching of Dixit et al. wherein such thickness optimization would have been obvious and would have been within the purview of one skilled in the art. The use of alternative refractory metals and metal nitrides and the use of conventional deposition methods would have been obvious and would correspond to obvious materials and deposition and planarization process and such would have been within the purview of one skilled in the art. The selection of high aspect ration and reduced submicron trench width and of etchback of the respective layers to the extent desired to form plugs employing conventional processing is well known in the art and is well within the purview of one skilled in the art and as such would have been obvious.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed plasma treatment of the titanium nitride since such is conventional and advantageous to improve barrier characteristics and wettability as taught by Ho et al., Hower et al., and Fu et al. It would have been obvious and would have been within the purview of one skilled in the art to have selected the desired conventional plasmas, the conventional electrical biasing and

rf signal, to have employed single chamber for deposition and annealing, and to have employed conventional alternative metal nitrides. Alternatively, official notice is given regarding any conventional plasmas, alternative metal nitrides enumerated in the claims that are not recited in the above and the use of electrical biasing and rf signal as claimed.

Regarding claims 32-39 and 51, note further that Ho et al. teach the use of two anneals, e.g., first anneal of nitrogen and second anneal of hydrogens. See, e.g., column 7 lines 4-27, column 10 lines 8-20.

It would have been obvious to one skilled in the art at the time the invention was made in practicing the above process to have employed two plasma anneals since such would permit the stuffing of the gases in the titanium nitride to improve barrier characteristics. The use of gas plasma is conventional and advantageous wherein the plasma would increase the stuffing in the barrier material.

Applicant's arguments filed March 26, 2001 have been fully considered but they are not persuasive.

The declaration filed on October 20, 1999 under 37 CFR 1.131 has been considered but is ineffective to overcome the Bai et al. reference and the references to Hower, Sandhu, and Fu.

The declaration and accompanying exhibit does not clearly explain which facts applicant is relying on to show completion of the invention prior to the effective reference date. It cannot be determined what exhibit A constitutes, whether it is the entire report, or the Table of Contents or pages 1, 2, 27-29, or which portion of exhibit A

is being relied upon. The section 4.8.2 of Exhibit A (p. 27) describes data for 50Å and 100Å CVD TiN films deposited upon 300Å titanium on silicon substrates, Figs. 25 and 26, pp. 28-29. It cannot be determined how the claimed invention can be realized from the data with regard to the plasma annealing step of the nitride. In addition, it is unclear regarding the information provided in exhibit A would correspond or commensurate with the range of the thicknesses claimed, e.g., as claimed in claims 21-23; it only shows a thickness of 300Å for Ti and two thicknesses of 50 and 100 Å for TiN are shown. It cannot be determined how the claimed invention would be reduced to practice given the information provided. The first paragraph on page 27 appears to show that 50Å there is close to 15% F at the interface as the report states that "these results ~~incidate~~ indicate a lower limit in the film thickness is required required to maintain an effective barrier to F penetration." This appears to contradict the claimed invention which requires no lower limit for the film thickness, only less than 130Å is recited thus correspond to an upper limit on the thickness, and not a lower one. It is further unclear how the two values recited would be commensurate with the claimed range. Additionally, other features of the claimed invention are not readily apparent. For instance, the channel having inner walls and the associated thickness cannot be found from the exhibit. The first sentence of the first paragraph on page 27, section 4.8.2., recites that a series of CVD TiN films were deposited on top of 300 Å PVD Ti on Si substrates. It cannot be determined how the tesing in fact demonstrate a solution to the problem intended to be solved by the invention. The exhibit relied upon by applicant thus fail to meet or show the limitations of the claims. The report or excerpt thereof insofar as can be determined appears to

primarily relate CVD TiN rather than establishing the requisite range or the invention as relating to the criticality of such thickness; the claimed invention does not appear to be limited to CVD TiN and further relates to specific thickness of central importance but not shown by the facts in the exhibit. It remains that applicant has failed to show how the exhibit as relied by applicant would sufficiently establish conception and reduction to practice of the claimed invention regarding the Bai reference. Applicant further alleges on page 7 last paragraph that the declaration would show the invention was conceived on or other reference to Hower, Sandhu, and Fu but fails to point out how the declaration, any specific allegations of facts, and any supporting facts would support such allegations.

Applicant further argues that Bai does not teach any sort of plasma treatment. Nonetheless, this fails to consider the advantages of such plasma treatment as taught by Fu, Hower, and Ho.

Applicant's argument regarding Winter v. Fujita and proposed rule making cannot be fully evaluated due to its vagueness and incomplete citation.

Applicant further argues that Dixit teaches that it is difficult to form pinhole-free barrier with thicknesses less than about 250Å. Dixit appears to prefer thickness over 250Å and does not appear to show that such pinhole-free barrier cannot be attained or that the barrier must always be pinhole-free. The barrier characteristics and adhesion constitute important considerations and the preponderance of evidence of record would support that the finding of obviousness of such the limitation on the thickness of TiN, namely that 10nm is sufficiently thick to suppress reactions and to maintain adhesion as

delineated in Suguro, the paragraph bridging page 280 and 290, wherein the thickness consideration regarding a SiO_2 sidewall in a deep contact hole.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to examiner Quach whose telephone number is (703) 308-1096. The examiner can normally be reached on Monday through Friday from 9 to 5.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Olik Chaudhuri, can be reached on (703) 306-2794. The fax phone number for the organization where this application or proceeding is assigned is (703) 308-7722.

Any inquiry of a general nature or relating to the status of this application or proceeding should be directed to the receptionist whose telephone number is (703) 308-0956.

Tuan Quach
Primary Examiner